ECL 62R

# ENGINEERING CASE LIBRARY

GENERAL ELECTRIC COMPANY

Vallecitos Atomic Laboratory

## Ventilation Exhaust Stack (A)

In summer, 1965, a construction company was extending a ventilation stack at General Electric's atomic laboratory[1] in Pleasonton, California. One of the construction engineers noticed cracks in the stack's concrete base and reported his observation to Mr. Bill Eagan. At that time Mr. Eagan was manager of an engineering unit in charge of equipment and facilities. The unit also designed set-ups for nuclear test experiments. Eagan discussed the situation with Don Brown, an engineer working under him. The two agreed that construction of the extension should proceed, since the cracks were small and the stack had stood for several years.

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[1]Vallecitos Nuclear Center is the largest privately-owned atomic energy laboratory in the country. It engages in the development of peacetime uses for atomic energy. The laboratory, which opened in 1957, presently employs about 700.



Prepared in the Design Division of the Department of Mechanical Engineering by David A. Horine. Revised April 1967 by Sue Hays, under the supervision of Professor Peter Z. Bulkeley, with support from the National Science Foundation. Assistance from Donald Brown of the General Electric Company is gratefully acknowledged.

The stack, which is shown in Exhibits 1 and 2, was built in 1957 to ventilate a laboratory test area. Air from the laboratory passes through a bank of filters and is then forced from the stack by fans. As time went on and operations expanded, the stack reached its maximum ventilating capacity of about 26,000 cubic feet per minute. The engineer who was in charge of ventilation suggested that a cone-shaped extension (Exhibit 3) be added. He believed that the cone would increase the stack's capacity by acting as a venturi nozzle and improving the flow pattern at the top of the stack. As use of the stack further increased, the speed of the exhaust fans was raised.

In early 1965, the ventilation system was again overloaded. This time, increasing the fan speed was not an adequate solution. It was decided to increase the stack's height above the level of nearby eucalyptus trees. Also, another bank of fans was to be added in parallel with the existing ones. These fans were to be located in a second access to the stack, which would join in at the lower edge of the new extension. After the fans were added, the capacity was 33,000 cubic feet per minute.

Before construction of the new extension was begun, a G. E. safety engineer examined the possibility that the extension might damage the stack[1] or cause it to fall over.

On the basis of his theoretical calculations, he concluded that even a wind of 90 mph would not overload the stack's anchor bolts (see Exhibit 4).

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[1]The stack was a steel plate rolled into a cylinder and bolted to a concrete base.

Shortly after work on the extension began in the summer of 1965, a construction engineer on the job reported to Mr. Eagan that the concrete base of the stack was cracked. There were small cracks at each anchor bolt location (Exhibit 1, insert). Each of the four severest cracks ran from an anchor bolt in a roughly vertical path down the base and appeared to continue into the ground.

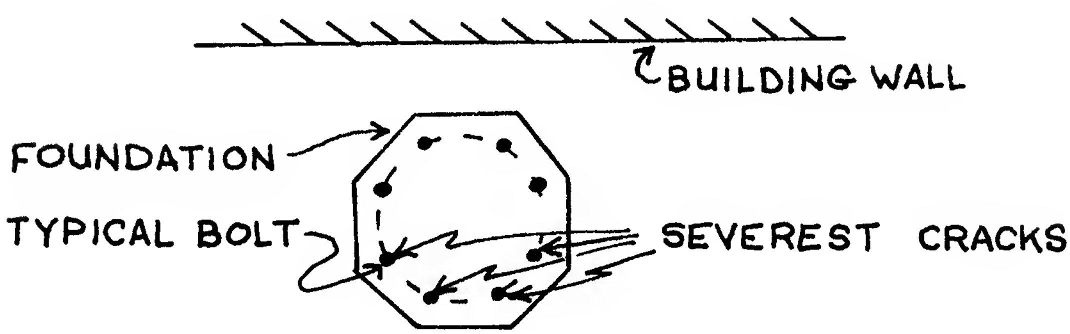
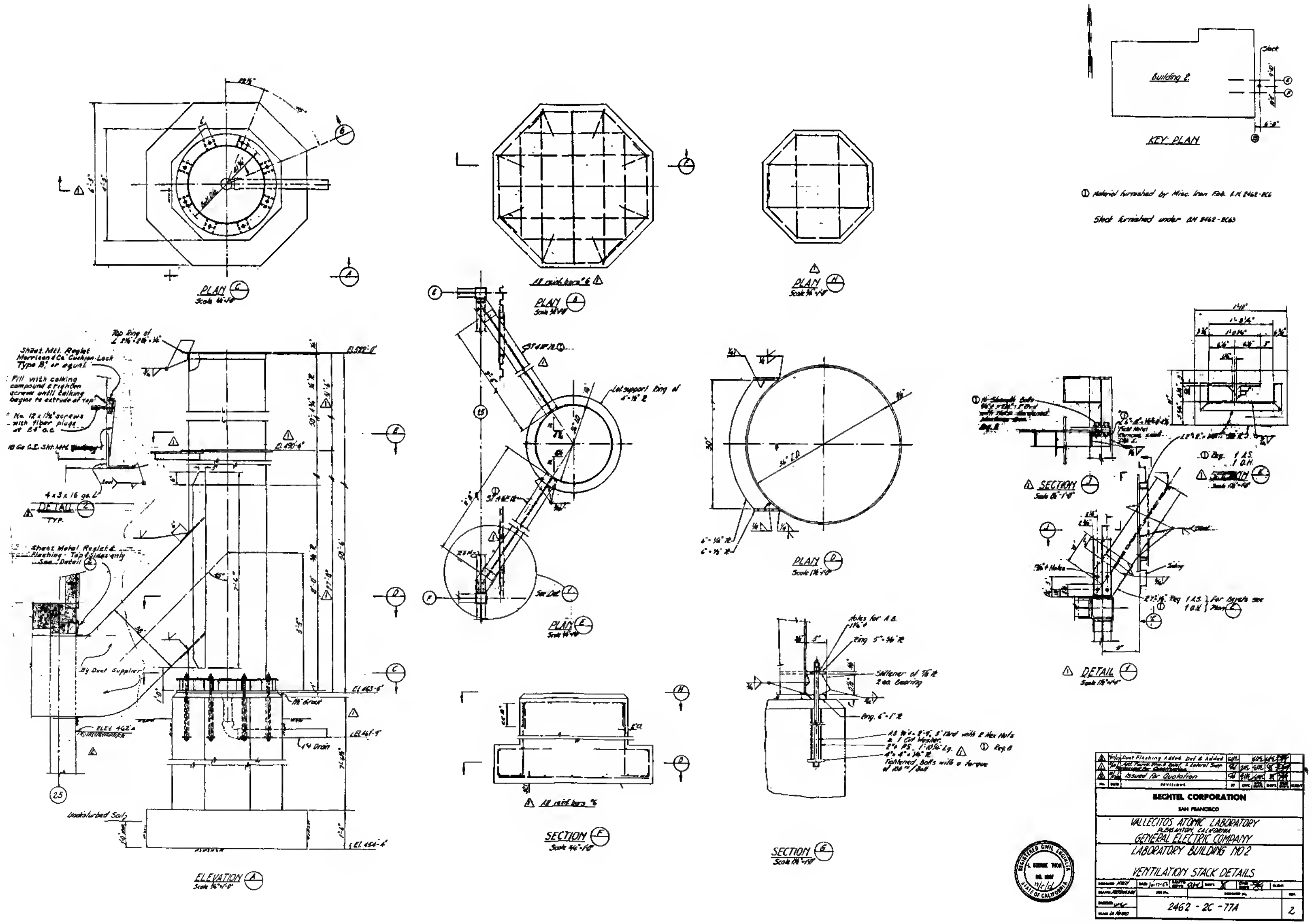


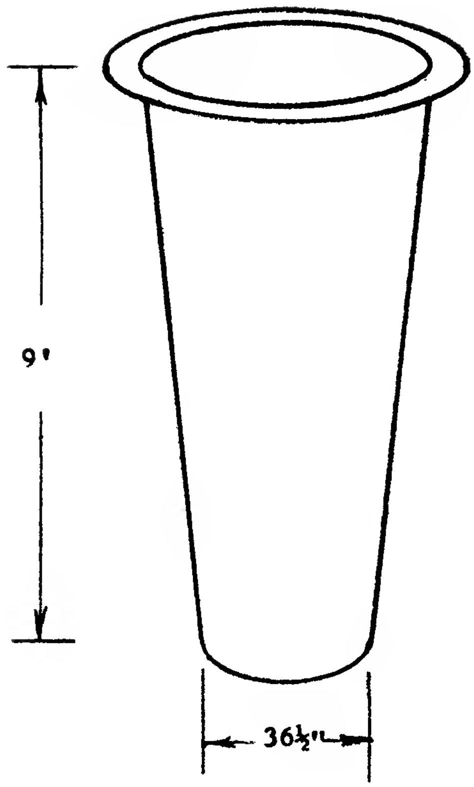

Exhibit 1, insert.

Exhibit 1



KEY PLAN
Building 2
Stack
① Material furnished by Misc. Iron Fab. B.M. 2462-8C6
Stack furnished under BM 2462-8C63
PLAN C
PLAN A
PLAN H
PLAN E
PLAN D
SECTION F
SECTION G
SECTION J
SECTION K
DETAIL 2
DETAIL L
ELEVATION A
Undisturbed Soil
By Duct Supplier
BECHTEL CORPORATION
SAN FRANCISCO
VALLECITOS ATOMIC LABORATORY
PLEASANTON, CALIFORNIA
GENERAL ELECTRIC COMPANY
LABORATORY BUILDING NO 2
VENTILATION STACK DETAILS
2462 - 2C - 77A


Exhibit 2




MATERIAL: ¼" STEEL PLATE

Exhibit 3

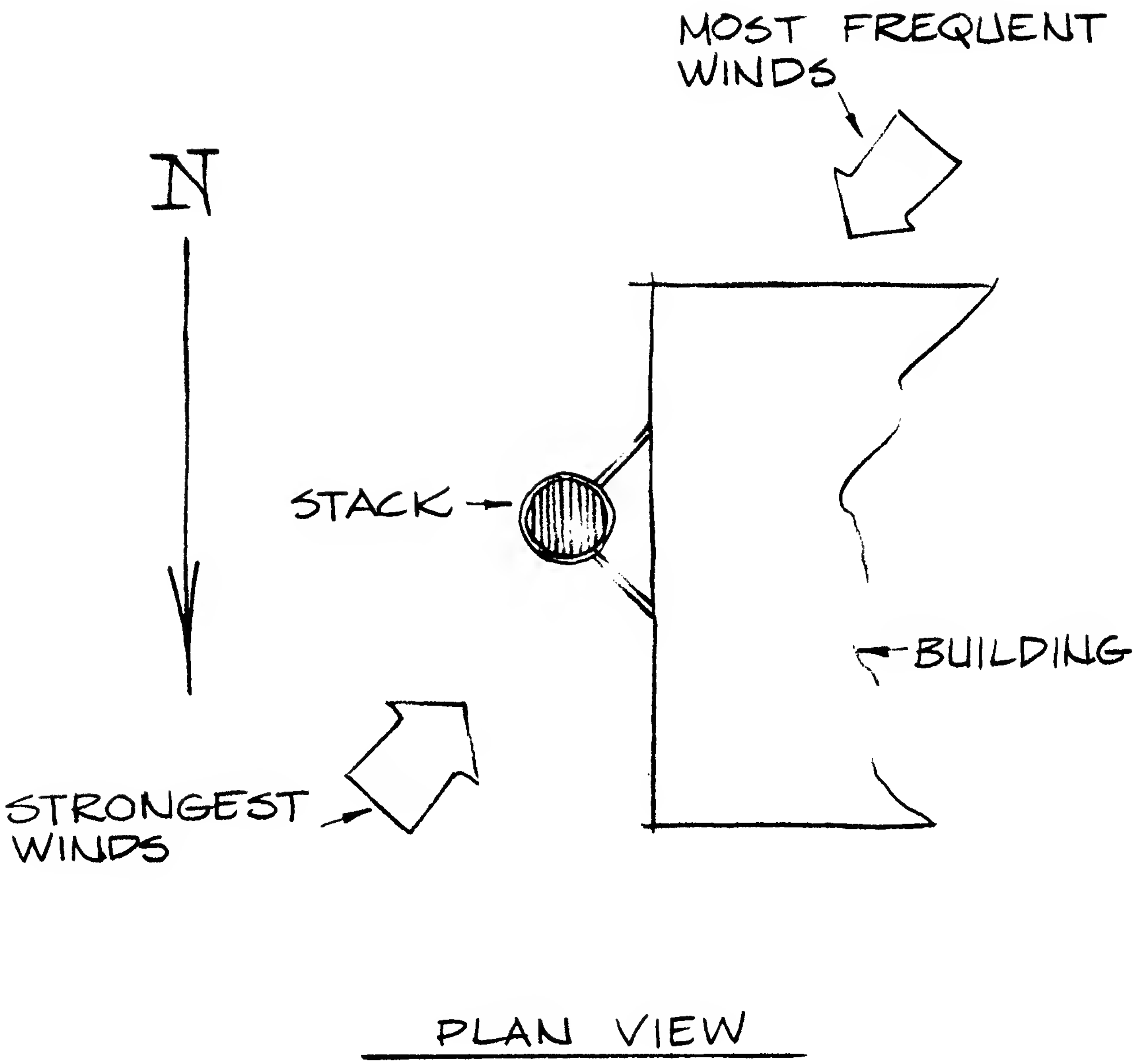

MOST FREQUENT WINDS
N
STACK
BUILDING
STRONGEST WINDS
PLAN VIEW

Exhibit 4.

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Ventilation Exhaust Stock (B)

Mr. Eagan then asked to see the safety engineer's theoretical analysis, which had been done on the basis of static wind loading. Eagan discussed the situation with Brown, and they agreed that wind-induced vibration might have caused the cracks. Brown then remembered seeing an article about wind-induced vibration in tall stacks in "Mechanical Engineering". Since the stack base was internally reinforced with steel rods, they didn't think the base could fail, even if the concrete should crack extensively. They regarded the stack as safe enough to sustain continued operation.

In autumn, 1965, Don was taking a graduate course in analysis of mechanical systems and needed a term project. He asked Mr. Eagan if he might do an analysis of the stack based on wind-induced vibrations for his project. He proposed to do the analysis on his own time and at little cost to the company. Mr. Eagan consented.

Since the stack did not seem to be in any immediate danger, they did not have work on the extension (Exhibit 5) stopped. There were no visible changes in the cracks after operation was resumed upon completion of the extension.

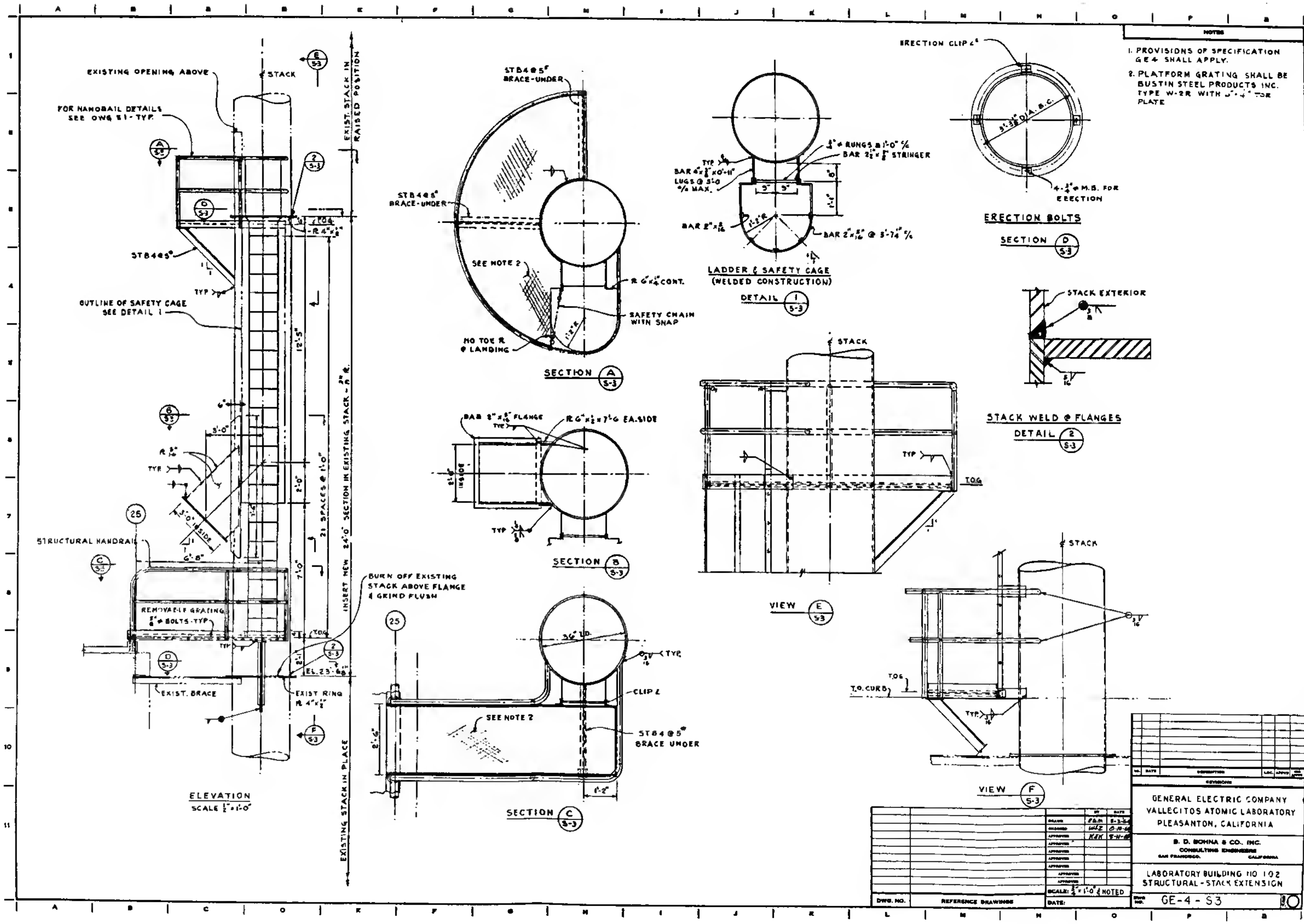
NOTES
1. PROVISIONS OF SPECIFICATION GE-4 SHALL APPLY.
2. PLATFORM GRATING SHALL BE BUSTIN STEEL PRODUCTS INC. TYPE W-2R WITH ¼" TOE PLATE
ELEVATION
SCALE ⅛"=1'-0"
SECTION A
SECTION B
SECTION C
SECTION D
ERECTION BOLTS
LADDER & SAFETY CAGE (WELDED CONSTRUCTION)
DETAIL 1
STACK WELD @ FLANGES
DETAIL 2
VIEW E
VIEW F
EXISTING OPENING ABOVE
FOR HANDRAIL DETAILS SEE DWG S1-TYP.
OUTLINE OF SAFETY CAGE SEE DETAIL 1
STRUCTURAL HANDRAIL
REMOVABLE GRATING
EXIST. BRACE
EXIST RING
EXIST. STACK IN RAISED POSITION
EXISTING STACK IN PLACE
BURN OFF EXISTING STACK ABOVE FLANGE & GRIND FLUSH
SEE NOTE 2
SAFETY CHAIN WITH SNAP
NO TOE R @ LANDING
STACK EXTERIOR
ERECTION CLIP
BRACE UNDER
GENERAL ELECTRIC COMPANY
VALLECITOS ATOMIC LABORATORY
PLEASANTON, CALIFORNIA
B. D. BOHNA & CO. INC.
CONSULTING ENGINEERS
LABORATORY BUILDING NO 102
STRUCTURAL - STACK EXTENSION
GE-4 - S3
REFERENCE DRAWINGS

Exhibit 5.

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Ventilation Exhaust Stack (C)

Mr. Brown proceeded to make an analysis of wind induced vibrations using Den Hartog[1] as his principal reference. In formulating his mathematical model of the stack, he made the following simplyifying assumptions:

1) The restraining members at the top of the building were assumed to be rigid and to exert no bending moments on the stack.
2) The mass of the sample station was lumped as an attached piece on the stack but the extra stiffness it imparts to the stack was neglected.
3) The effect of the duct work was neglected at both the top of the building and near the base, i.e., the mass per unit length and the moment of inertia used were those of a cylinder with the local material thickness.
4) The ladder was neglected.
5) Fan-induced vibration was ignored.

Brown's valculations indicated the possibility of the stack's coming into resonance at a wind velocity of 11 mph with a resonant frequency of 1.2cps. At this wind speed, the forcing function would have a maximum value of 57 pounds for the section of the stack exposed to the winds above the building.

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[1] J.P. Den Hartog; Mechanical Vibrations, third edition; McGraw-Hill Book Co. Inc., 1947; p. 373.

The following is Mr. Brown's description of his attempt to verify the natural frequency of the stack empirically:

> "This was accomplished by standing on the sample station platform and exciting the stack with body motion. Using this method the stack was brought into resonance at approximately one cycle per second and the excitation was continued until an amplitude of roughly two inches was obtained at the sample station level. An interesting result of this test was the observation that in a direction parallel to the building the above results were obtained, but in the direction perpendicular to the building the natural frequency was apparently several times as large and in several tries resonance was not reached. Thus the stiffness of the system is directional dependent, but is very nearly as I have assumed in the one direction. Whether or not the stack goes into resonance depends not only on wind velocity but also on wind direction."

Brown concluded that there might be a possibility of further damage to the stack from wind-induced vibrations and recommended that a guy wire-damper system be installed.

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Ventilation Exhaust Stack (D)

In January, 1966, R.J. Bogosich, who was on a rotating job training program and was at that time in Facilities Engineering, designed a damper system. He proposed to guy the stack with a shock absorber-spring arrangement (Exhibit 6). "Load Leveler" type automobile shock absorbers were to be used. He estimated that the total cost of adding guy wires, including the hardware, labor and drafting needed, would be about $1000.

Mr. Eagan decided to have the guy wires installed. He recognized that the cracks could have been caused by any number of circumstances such as a poor concrete mixture or thermal expansion of the anchor bolts. However, Don Brown's analysis seemed to indicate that guy wires should be added and the cost of this was small. Rather than spend more time and money making a detailed analysis of the situation, Mr. Eagan decided to go ahead and have the guy wires installed.

Three guy wires spaced at 120° intervals were attached to the stack at the lower edge of the cone. Each wire was strung through a hole made in the ring at the lower edge of the cone (Exhibit 2).

The guy wires, which were 3/16" steel cable, made a 60° angle with the stack which was about seventy feet tall at the base of the cone. The shock absorbers were mounted in concrete slabs buried in the ground (Exhibit 7). The guy wire damper system was in place by April, 1966, and actually cost about $1200. No change has been observed in the cracks since the addition of the wires.

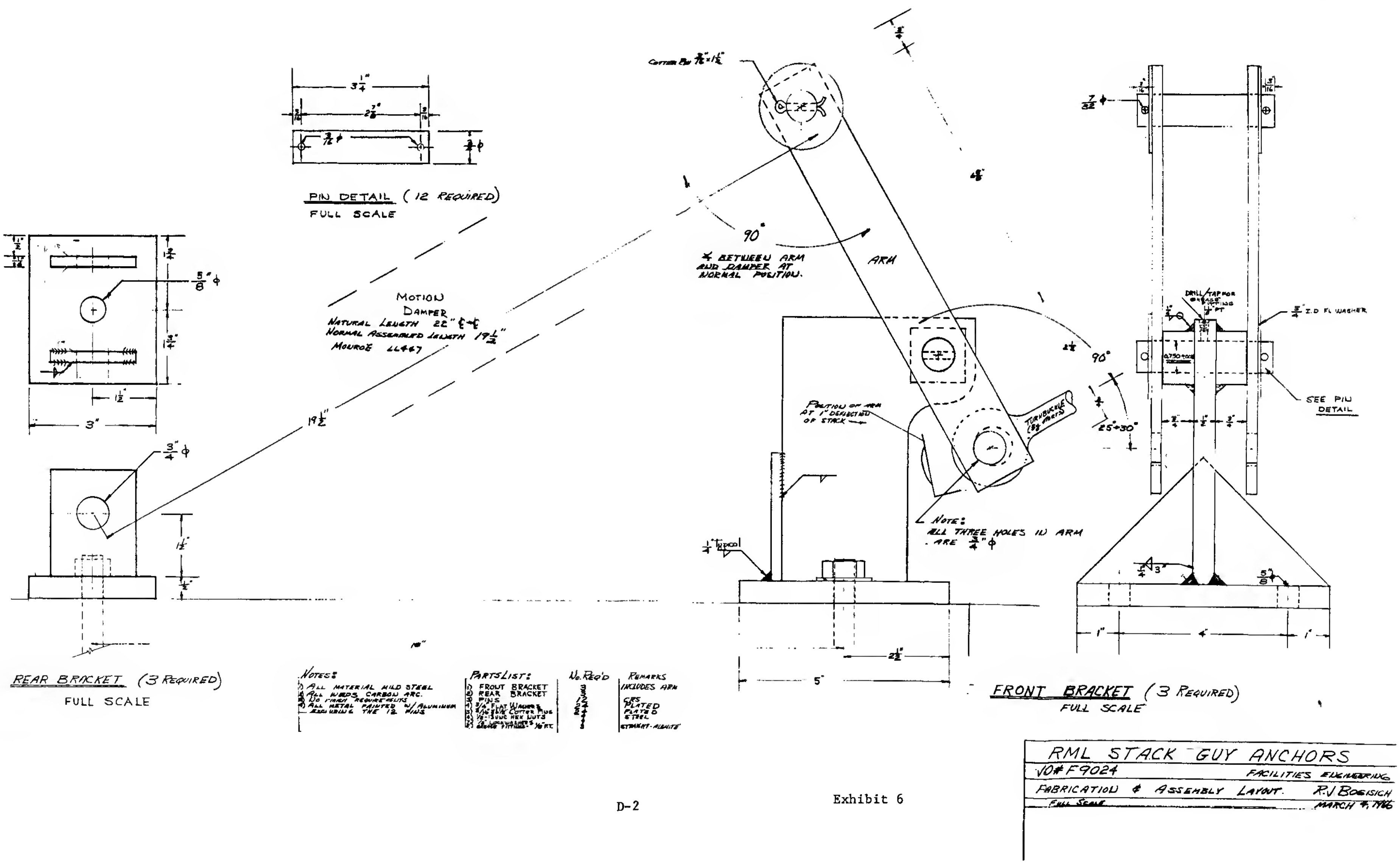
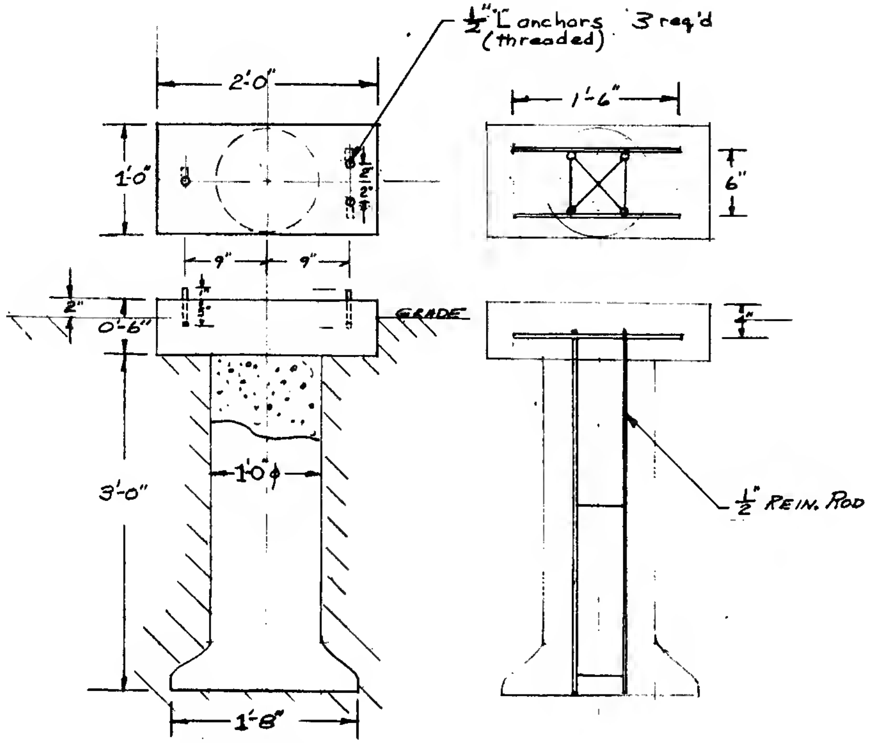

PIN DETAIL (12 REQUIRED)
FULL SCALE
REAR BRACKET (3 REQUIRED)
FULL SCALE
MOTION DAMPER
NATURAL LENGTH 22" ℄-℄
NORMAL ASSEMBLED LENGTH 19½"
MONROE LL467
ARM
∢ BETWEEN ARM AND DAMPER AT NORMAL POSITION.
POSITION OF ARM AT 1" DEFLECTION OF STACK
NOTE: ALL THREE HOLES IN ARM ARE ¾" ϕ
¾" I.D FL WASHER
SEE PIN DETAIL
FRONT BRACKET (3 REQUIRED)
FULL SCALE
NOTES:
1) ALL MATERIAL MILD STEEL
2) ALL WELDS CARBON ARC.
3) NO FINISH REQUIREMENTS
4) ALL METAL PAINTED W/ALUMINUM EXCLUDING THE 12 PINS
PARTS LIST:
1) FRONT BRACKET
2) REAR BRACKET
3) PINS
4) 3/4 FLAT WASHERS
5) COTTER PINS
6) 1/2-13UNC HEX NUTS
7) 1/2 LOCKWASHERS
8) GREASE FITTINGS
NO. REQ'D
3
3
12
24
24
REMARKS
INCLUDES ARM
CRS
PLATED
PLATED
STEEL
RML STACK GUY ANCHORS
VO# F9024
FACILITIES ENGINEERING
FABRICATION & ASSEMBLY LAYOUT.
R.J BOGISICH
FULL SCALE
MARCH 4, 1966

Exhibit 6

RML STACK GUY SYSTEM
VO# F9024




DETAILS - CONCRETE PIER (3 REQ'D)

Scale 1"=1'

NOTE:

1. 3 - 12"φ holes by General Electric Co.
2. Contractor will supply all reinforcing rod, anchor bolts, and forms.
3. Concrete will be five sack mix.
4. Top surface of piers will be finished to provide a flat mounting surface.
5. All other hardware will be supplied by General Electric Co.
6 Contractor will be responsible for installation of all hardware. This will include three vibration dampers, guy wires, and the three coble eyes at the 85' level on the stack.
7. All work is subject to approval by the facilities engineering representative

| MADE BY R.J Boeisich 2-17-66 | | SK56100-280 |
|---|---|---|

Exhibit 7